Ministry
of
Transportation
Ontario

MI-127

A LABORATORY EVALUATION OF CONCRETE SURFACE SEALANTS

(PHASE 2)

MATERIALS INFORMATION
ENGINEERING MATERIALS OFFICE

A LABORATORY EVALUATION OF CONCRETE SURFACE SEALANTS PHASE 2

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CONCRETE SECTION
NOVEMBER 1988

SUMMARY

Ten concrete surface sealants were evaluated for their effectiveness in increasing the resistance of concrete to penetration by water and chloride ions, and to salt scaling. The treated concrete was also tested for moisture vapour permeability and rapid chloride permeability. All tests were carried out using concretes with low and normal air contents.

Seven of the sealants exhibited adequate salt scaling resistance and four of the sealants showed adequate resistance to both salt scaling and ingress of chloride ions.

The rapid chloride permeability test shows promise as a quick test for comparative sealant performance. It is recommended that more work be carried out examining this procedure.

TABLE OF CONTENTS

		Page
1.0	Introduction	1
2.0	Properties Governing Sealant Performance	1
3.0	Sealants Tested	2
4.0	Test Procedures	
4.1	Concrete Mix	3
4.2	Specimen Casting, Curing and Preparation	4
4.3	Application of Sealants	4
4.4	Depth of Penetration	5
4.5	Water Absorption	5
4.6	Water Vapour Transmission	5
4.7	15% NaCl Solution - Absorption and Vapour Transmission	6
4.8	Chloride Ion Content	6
4.9	Salt Scaling Resistance	6
4.10	Rapid Chloride Permeability	7
5.0	Test Results and Discussion	7
5.1	Depth of Penetration	8
5.2	Surface Discolouration	8
5.3	Water Absorption	8
5.4	15% NaCl Absorption	9
5.5	Salt Scaling and Choride Ion Penetration	9
5.6	Vapour Transmission	10
5.7	Rapid Chloride Permeability	11
6.0	Field Performance	13
7.0	General Discussion and Requirements	13
7.1	Scaling	13
7.2	Chloride Ion Penetration	13
7.3	Scaling and Chloride Ion Penetration	14
8.0	Conclusions and Recommendations	14
References		17
Appendix A	Data Tables	
Appendix B	List of Suppliers	

LIST OF FIGURES AND TABLES

Figure		Page
1	Absorption Comparison	8
2	Chloride Ion Content vs. Rapid Chloride Permeability	12
3	Absorption in 15% NaCl vs. Rapid Chloride Permeability	12

Table		
A	Sealant Physical Properties	2
B	Concrete Mix Proportions and Fresh Concrete Properties	3
C	Application Rates	4
D	Penetration and Absorption Results	7
E	Salt Scaling and Soluble Chloride Ion Results	9
F	Vapour Transmission	10
G	Rapid Chloride Permeability	11
H	Data - Absorption in Water	Appendix A
I	Data - Absorption in 15% NaCl	"
J	Data - Salt Scaling	"
K	Data - Vapour Transmission	"

LABORATORY EVALUATION OF CONCRETE SURFACE SEALANTS

1.0 INTRODUCTION

Freezing conditions and the use of deicing salt on highways cause two types of concrete distress, spalling and surface scaling. Spalling is the detachment of concrete fragments from a larger mass caused by expansion within the mass. It occurs when salt penetrates the concrete down to the reinforcing steel causing corrosion of the steel. Scaling is the flaking away of the surface mortar. The two types of distress manifest themselves mainly in bridge decks, parapet walls, structural barrier walls, retaining walls, abutments, piers and columns. Sidewalks and curbs do not contain reinforcing steel so they are vulnerable only to surface scaling.

Neither of the two types of distress occur where the concrete is well air entrained, its water-cement ratio is not excessive, the reinforcing steel is epoxy coated and there is an adequate concrete cover to the steel. However, where for any reason one of the above requirements is not satisfied, a surface treatment may be desirable to prevent deicing salt penetrating the concrete. Most Ministry surface sealant applications involve vertical surfaces.

There are many concrete coatings and penetrating sealants available on the market in Ontario. However, it is difficult to select a suitable product without prior testing information to ensure that it will perform adequately. To evaluate the effectiveness of these products a laboratory testing program was carried out during September 1984 - March 1985. The evaluation and its results were presented in an earlier report[1].

This report details the continuation of the sealant evaluation. Some test procedures were changed so as to approximate tests carried out by other agencies, namely those tests reported in NCHRP Report 244[2]. In addition, the salt scaling test was performed since salt scaling is a major concern in Ontario.

A number of new barrier walls were treated with Dekguard, Cap Seal X and SN 502 in 1984. These sections have been monitored for salt scaling resistance at intervals between 1984 and 1988. The results are discussed in Section 6.0, Field Performance.

It has been reported[3] that the rapid chloride permeability test may have some applicability in evaluating sealants. Therefore, tests were run using this method to examine correlation with other tests and possible future use.

2.0 PROPERTIES GOVERNING SEALANT PERFORMANCE

The Ministry occasionally uses surface sealants to prevent the penetration of concrete by deicing salt on non-traffic surfaces such as barrier walls, abutments and retaining walls. Surface sealants are not used on traffic surfaces such as pavements and bridge decks as they are in Alberta[4]. For this reason, wear and skid resistance properties are not evaluated by this study. The following properties, as determined on concrete treated with a sealant, govern the performance of penetrating sealants:

i) penetration depth - sealants which penetrate the concrete substantially should be more durable.

ii) water absorption - to prevent saturation of the concrete, the sealant should not let excessive amounts of water enter the concrete.

iii) moisture vapour transmission - the sealant should allow the concrete to breathe to relieve water vapour pressure build up under the sealed surface.

iv) chloride penetration - the treated concrete surface should prevent the ingress of excessive amounts of chloride ions into the concrete to prevent the corrosion of reinforcing steel.

v) salt scaling resistance - the treated concrete surface should be resistant to the destructive action of freezing and thawing in the presence of deicing salt and to thermal volume changes.

All the above properties with the possible exception of the penetration depth will govern the performance of a concrete coating. In addition, a concrete coating must form a good bond to the concrete surface. The salt scaling test also evaluates the quality of the bond.

3.0 SEALANTS TESTED

Ten proprietary sealants were included in the project. Each was tested for non-volatile content, relative density, and pH value. Table A lists the sealants, their chemical type (as described by the manufacturer) and physical characteristics.

The non-volatile contents were determined on 10 g samples dried overnight at 105°C. The relative densities were determined at 25°C with a Westphal balance.

The pH values were determined by shaking 50 mL of the sealant with 50 mL of distilled water and reading the pH of the aqueous extract.

TABLE A: SEALANT PHYSICAL PROPERTIES

SEALANT	TYPE*	p. H.	NON-VOL. CONTENT (%)	RELATIVE DENSITY
HYDROZO 30M	Blend of natural oils & resins, silane, siloxane, stearates & aluminum compounds	4.72	24.1	0.8341
HYDROZO 650	Blend of silane, siloxane, stearates & aluminum compounds	4.54	7.0	0.8182
SALTGUARD 12%	Oligomeric Organosilane	4.63	10.1	0.8164
CPD PAVER	Methyl/Butyl Methacrylate	3.48	19.2	0.9048
SM DECK SEAL - TOP COAT	Methylmethacrylate	3.39	28.4	0.9270
- PRIMER	Silane	6.02	4.0	0.8025
SN 502	Oligomeric Alkoxy Siliane	6.40	7.1	0.8223
CAP SEAL X	Silane monomer	6.26	NIL	0.8255
CHEMTRETE BSM 40	Alkyl trialkoxy silane	7.52	NIL	0.8385
STIFEL S	Alkyl-alkoxy silane	6.01	11.7	0.8938
PROTEKRETE	Silane-siloxane	5.50	15.9	0.8378

* as described by the manufacturer

4.0 TEST PROCEDURES

4.1 Concrete Mix

Testing was carried out on two sets of specimens; one set made of air entrained concrete and the other made of concrete with a low air content. Table B shows the mix proportions and fresh concrete properties.

Batches of each mix were made and tests carried out in accordance with CSA CAN3-A23.2[5]. All materials complied with MTO requirements [6,7].

The compressive strength at 28 days averaged 39.5 MPa for the air entrained concrete and 43.5 MPa for the non-air entrained concrete.

TABLE B: CONCRETE MIX PROPORTIONS AND FRESH CONCRETE PROPERTIES

	NON-AIR ENTRAINED CONCRETE	AIR ENTRAINED CONCRETE
MIX PROPORTIONS (Based on dry mass)		
Coarse Aggregate, kg -dolomitic limestone 19.0 mm nom. max. size	54.6	54.6
Fine Aggregate, kg -natural sand	41.5	36.2
Cement, Type 10, kg	17.8	17.8
Water, kg	9.10 - 9.15	8.40 - 8.60
Water Reducing Admixture, ml -PDA 25 XL	50.7	50.7
Air Entraining Admixture, ml -Pro Air	NIL	4.3 - 4.8
FRESH CONCRETE TESTS		
Slump, mm	80 ± 10	80 ± 10
Air Content, %	3.5 ± 1.0	6.0 ± 1.0
Cement Content, kg/m3	345 ± 5	355 ± 5
Effective W/C	0.447	0.417

4.2 Specimen Casting, Curing and Preparation

Five 150 x 150 x 50 mm and two 300 x 300 x 75 mm slabs were cast for each sealant. They were compacted by rodding and finished in accordance with ASTM C 192-81[8]. Each slab was moist cured for 14 d followed by 14 d curing at normal laboratory air conditions.

Cylinders, 100 x 200 mm, were cast for 28 d strength and rapid chloride permeability. Strength cylinders were moist cured for 28 d while cylinders for rapid chloride permeability were moist cured for 14 d followed by 14 d curing at normal laboratory air conditions.

All surfaces to be treated were lightly sandblasted prior to any application of sealant.

4.3 Application of Sealants

Each sealant, with the exception of Chemtrete BSM 40 and Protekrete, was applied by brushing it on to the concrete surface at the rate recommended by its manufacturer. Chemtrete was sprayed on as recommended by its manufacturer. Table C shows the application rate for each of the sealants tested.

TABLE C: APPLICATION RATES

SEALANT	Rate of Application per coat, m2/L	Number of coats
HYDROZO 30M	3.06	1
HYDROZO 650	3.06	1
SALTGUARD 12%	3.06	1
CPD PAVER	3.06	1
SM DECK SEAL - TOP COAT	2.56	1
- PRIMER	5.12	1
SN 502	2.50	1
CAP SEAL X	3.00	1
CHEMTRETE BSM 40	3.06	1
STIFEL S	3.10	1
PROTEKRETE	3.06	1

4.4 Depth of Penetration

Each sealant was applied to the top surface of a 150 x 150 x 50 mm slab and allowed to cure for 14 d at normal laboratory conditions. The slab was then cut into four 75 x 75 x 50 mm blocks. The blocks were immersed in water for approximately one minute to delineate the depth of penetration. Two readings to the nearest 0.5 mm were taken on each sawcut side of each block. The average of the 16 measurements was recorded as the depth of penetration.

A water soluble dye was used as a check on several samples and confirmed original readings.

4.5 Water Absorption

Each sealant was applied to all sides of each of two 150 x 150 x 50 mm slabs and cured for 14 d at normal laboratory conditions. Each specimen was weighed and immersed in water, with approximately 25 mm of water covering the top of the slab, for 21 d at normal laboratory conditions.

Each specimen was surface dried and weighed at 1, 3, 7, 14 and 21 d of water immersion.

The absorption was calculated from the following formula:

$$\text{Absorption, \%} = \frac{B - A}{A} \times 100\%$$

Where A = initial mass of the slab and sealant prior to immersion in water.

B = mass of the slab and sealant after water immersion.

All measurements were recorded to the nearest 0.1 g and the reported absorption was the average of the two slabs.

4.6 Water Vapour Transmission

At the completion of the 21 d immersion period for water absorption, the slabs were dried at normal laboratory conditions (Temp. 25°C ±, Humidity 34% ±) for 21 d . Each specimen was weighed at 1, 3, 7, 14 and 21 d of the drying period. The water vapour transmission was calculated from the following formula:

Vapour Transmission, %

$$= \frac{\text{mass of water lost in drying}}{\text{mass of water gained from immersion}}$$

$$= \frac{C - D}{C - A} \times 100\%$$

Where A = initial mass of the slab and sealant prior to water immersion in the absorption testing.

C = mass of the slab and sealant at the start of the drying period.

D = mass of the slab and sealant after drying.

All measurements were recorded to the nearest 0.1 g and the reported vapour transmission was the average of the two slabs.

4.7 15% NaCl Solution - Absorption And Vapour Transmission

The procedures were the same as previously described for water absorption and vapour transmission except that the specimens were immersed in a 15% NaCl solution.

4.8 Chloride Ion Content

After 21 d drying for vapour transmission, the specimens which had been immersed in the 15% NaCl solution were wire brushed to remove surface salt. One slab for each sealant was cut into four 75 x 75 x 50 mm blocks and one block was crushed to determine chloride ion content. The water soluble chloride ion contents were determined in accordance with MTO Test Method for Determination of Water Soluble Chloride Ion Content in Concrete, LS 411.

Two blocks of air entrained concrete not immersed in the 15% NaCl solution were also tested for background chloride ion levels. The results reported have been corrected by subtracting the background levels.

4.9 Salt Scaling Resistance

Each sealant was applied to the top surface of each of two 300 x 300 x 75 mm slabs and cured for 14 d at normal laboratory conditions. For the salt scaling slabs, the test was carried out in accordance with ASTM C672-84 with the following modifications:

1) Precast dykes were secured with a mortar mix to a matching recess cast along the perimeter of the slab and sealed with an epoxy.

2) Where salt scaling tests could not begin after 28 d, the slabs were wrapped in plastic bags and stored at -18 ± 2°C until testing could commence.

3) The deicing agent was a 3% sodium chloride solution.

4) The cumulative mass loss was determined after each 5 cycles of freezing and thawing for each slab and averaged for the pairs. The mass loss is the dry mass of the flaked off concrete.

4.10 Rapid Choride Permeability

After curing, a series of 100 x 200 mm cylinders each were cut into three 50 mm thick disks and labelled to indicate cylinder number and location (i.e. top, middle and bottom parts of the cylinder). These disks were sealed in plastic bags and stored at -18 ± 2°C until testing commenced.

Each sealant was applied to three disks, the top, middle and bottom part of the cylinder to show any possible variation in cylinder density.

The sealants were applied to both surfaces of each disk and allowed to cure for 14 d at normal laboratory conditions. This procedure was taken from the work done by D. Whiting[3]. The only variation from this procedure was in initial curing of the specimens. D. Whiting's procedure called for 14 d moist then 7 d air dry curing while we air dried for 14 d after 14 d of moist curing. The disks were then tested in accordance with AASHTO Designation T 227-83 "Rapid Determination of the Chloride Permeability of Concrete" [10].

5.0 TEST RESULTS AND DISCUSSION

Table D shows the results of the depth of penetration, water absorption and 15% NaCl absorption after 21 d of soaking. It also shows the calculated value for percent reduction in absorption compared to the untreated control.

TABLE D: PENETRATION AND ABSORPTION RESULTS

SEALANT NAME	DEPTH OF PENETRATION (mm)		WATER ABSORPTION, % (soaking 21 days)				15% NaCl ABSORPTION, % (soaking 21 days)			
			AIR ENTRAINED		NON-AIR ENT.		AIR ENTRAINED		NON-AIR ENT.	
	A/E	NON A/E	Value	% Red'n*	Value	% Red'n*	Value	% Red'n*	Value	% Red'n*
CONTROL	-	-	2.32	-	1.76	-	2.22	-	2.13	-
HYDROZO 30M	0.6	0.5	1.45	38	0.83	53	0.56	75	0.65	69
HYDROZO 650	0.3	0.8	1.30	44	0.90	49	0.66	70	0.66	69
SALTGUARD 12%	0.4	0.6	0.98	58	0.84	52	0.51	77	0.54	75
CPD PAVER	0.3	0.2	1.40	40	0.93	47	0.69	69	0.84	61
CHEMTR BSM 40	1.3	0.8	1.94	16	1.67	5	0.96	57	1.34	37
SM DECK SEAL	0.9	1.0	0.76	67	0.48	73	0.35	84	0.26	88
CAP SEAL X	1.5	0.2	1.69	27	1.53	13	0.86	61	1.12	47
SN 502	0.5	0.9	1.20	48	1.09	38	0.50	77	0.61	71
STIFEL S	1.3	0.1	1.35	42	1.42	19	0.66	70	1.15	46
PROTEKRETE	1.4	0.1	2.13	8	1.75	1	0.81	64	0.79	63

* Percent reduction in absorption compared to the control

5.1 Depth of Penetration

None of the sealants tested had penetrations in excess of 1.5 mm. Repeat tests confirm these findings. This conflicts with results obtained in MI-79 where both Cap Seal X and Chemtrete exhibited penetrations greater than 10 mm. This difference cannot be satisfactorily explained.

5.2 Surface Discolouration

Of the sealants applied, only SM Deck Seal and CPD Paver caused obvious discolouration. The discolouration was slight, only a darkening of the concrete surface.

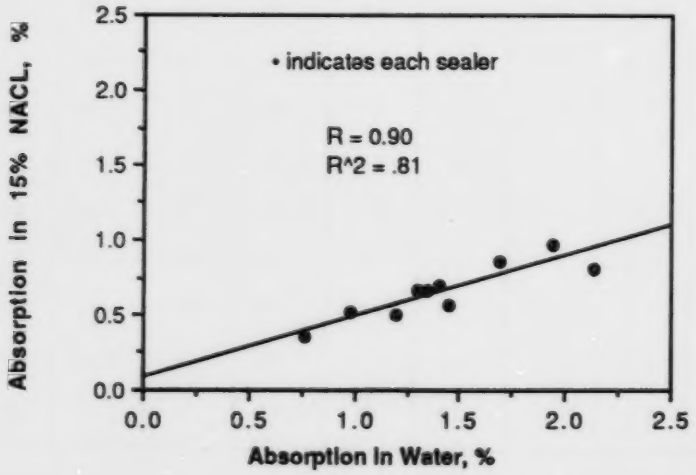
5.3 Water Absorption (Table H, Appendix A)

After 21 d of soaking the untreated control specimens had absorptions of 2.32% for the air entrained concrete and 1.76% for the non-air entrained concrete. These values are significantly lower than those in MI-79 due to a difference in the testing procedure. In MI-79 the specimens were oven dried prior to immersion, while the specimens tested for this report were air dryed for 14 d only as per the NCHRP 244 report [2] procedures. Further study has shown that oven drying of the concrete prior to the absorption test will increase the values by approximately 2-3%.

All treated specimens showed reductions in water absorption based on the control, however, only Saltguard 12% and SM Deck Seal had reductions greater than 50% for both air entrained and non-air entrained specimens.

Figure 1 is a plot of water absorption versus absorption in 15% NaCl for treated air entrained specimens.

FIGURE 1: Absorption Comparision



It can be seen that the correlation between these two tests is quite strong. For future testing the water absorption test will be dropped.

5.4 15% NaCl Absorption (Table I, Appendix A)

The treated specimens show reductions in absorption based on the control of 37% to 88% after 21 d of soaking in the 15% NaCl solution.

5.5 Salt Scaling and Chloride Ion Penetration (Table J, Appendix A)

Table E shows the results of the salt scaling test after 50 cycles and the soluble chloride ion content.

TABLE E: SALT SCALING AND SOLUBLE CHLORIDE ION RESULTS

SEALANT NAME	SALT SCALING (Kg/m^2) (after 50 cycles)		SOLUBLE CHLORIDE ION CONTENT ION CONTENT** (% by Mass)			
			AIR ENTRAINED		NON-AIR ENTRAINED	
	A/E	NON A/E	Value	% Reduct.*	Value	% Reduct.*
CONTROL	0.171	5.598	0.2630	-	0.2572	-
HYDROZO 30M	0.057	0.444	0.0360	86	0.0564	78
HYDROZO 650	0.161	1.862	0.0405	85	0.0501	81
SALTGUARD 12%	0.027	0.392	0.0246	91	0.0459	82
CPD PAVER	0.081	0.438	0.0634	76	0.0817	68
CHEMTR BSM 40	1.116	1.037	0.0626	76	0.1224	52
SM DECK SEAL	0.030	0.054	0.0089	97	0.0023	99
CAP SEAL X	0.673	2.632	0.0710	73	0.1066	59
SN 502	0.089	0.658	0.0328	88	0.0462	82
STIFEL S	0.070	0.084	0.0300	89	0.0934	64
PROTEKRETE	0.126	0.116	0.0464	82	0.0487	81

* Percent reduction of chloride content compared to the untreated control
** Values have been adjusted for background chloride levels

The water soluble chloride ion content of the treated specimens was reduced 52 to 99% based on the untreated control. These values are based on the total soluble chloride ion in the specimen and not at a specific depth.

In the salt scaling test, the current acceptance guideline used by the Ministry for precast concrete is a maximum mass loss of 0.8 kg/m2 at 50 cycles. All of the air entrained specimens, with the exception of Chemtrete, were within this requirement. Chemtrete and Cap Seal X exhibited substantially more scaling than the control for air entrained concrete.

The non-air entrained specimens were also within this limit except for Chemtrete, Hydrozo 650, Cap Seal X and the untreated control.

5.6 Vapour Transmission (Table K, Appendix A)

Table F shows the values for vapour transmission after 21 d of drying.

TABLE F: VAPOUR TRANSMISSION

SEALANT NAME	WATER VAPOUR TRANSMISSION, % (after 21d drying)		15% NaCl VAPOUR TRANSMISSION, % (after 21d drying)	
	A/E	NON A/E	A/E	NON A/E
CONTROL	80.6	95.0	64.1	55.9
HYDROZO 30M	89.2	108.6	122.0	86.1
HYDROZO 650	91.8	102.3	112.2	82.8
SALTGUARD 12%	96.2	106.8	133.8	94.4
CPD PAVER	90.2	99.8	115.0	76.8
CHEMTR BSM 40	85.0	91.8	102.9	60.5
SM DECK SEAL	119.3	136.8	174.5	142.1
CAP SEAL X	86.2	88.1	98.0	67.9
SN 502	105.2	96.3	145.6	90.9
STIFEL S	90.8	91.6	124.5	69.1
PROTEKRETE	93.9	90.2	103.1	82.1

All treated specimens of air entrained concrete exhibited better vapour transmission than the untreated control for both soaking in water and 15% NaCl. This can be explained by the fact that the treated specimens absorbed much less water than the control during soaking. Four sealants showed marginally lower vapour transmission than the control for the non-air entrained specimen soaked in water.

Values greater than 100% were common for treated specimens indicating higher moisture loss than they originally absorbed. This is probably due to continued drying of the specimens as they were not oven dried prior to initial weighing and also the possible loss of sealant due to evaporation.

5.7 Rapid Chloride Permeability

Table G gives the results of the rapid chloride permeability test for the air entrained specimens. The results for the non-air entrained specimens were not complete at time of publication.

TABLE G: RAPID CHLORIDE PERMEABILITY, Coulombs

SEALANT	A	B	C	AVERAGE
CONTROL	2797	4220	2260	3092
HYDROZO 30M	1131	724	782	879
HYDROZO 650	1015	874	796	895
SALTGUARD 12%	755	481	457	564
CPD PAVER	951	766	1281	999
CHEMTRETE BSM 40	1026	1335	795	1052
SM DECK SEAL	327	320	248	298
CAP SEAL X	1030	911	787	909
SN 502	746	616	571	644
STIFEL S	687	865	436	663
PROTEKRETE	589	575	532	565

The specimen number in Table G corresponds to the specimen location in the cylinder; A being the top section, B the middle section and C the bottom section. The bottom section of the cylinder, with one exception, yielded the lowest result

for all sealants. This is to be expected as the bottom of the cylinder tends to be denser than the top.

Figures 2 and 3 compare the average rapid chloride permeability to soluble chloride ion content and absorption in 15% NaCl respectively for each sealant for air entrained specimens.

FIGURE 2: Chloride Ion Content vs Rapid Chloride Permeability

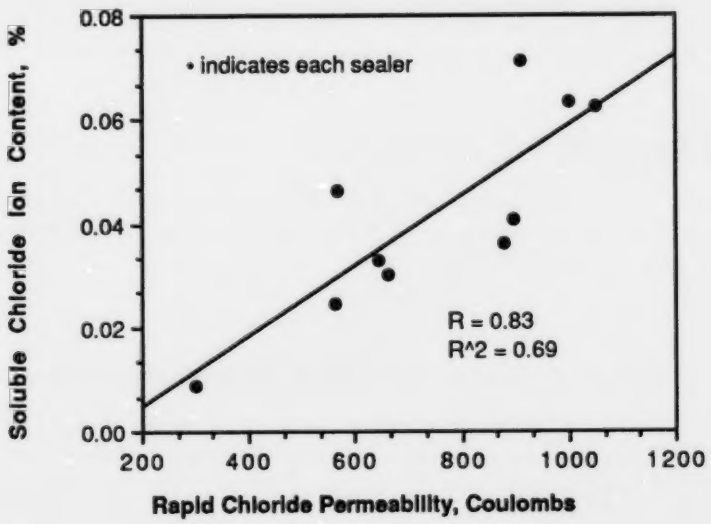
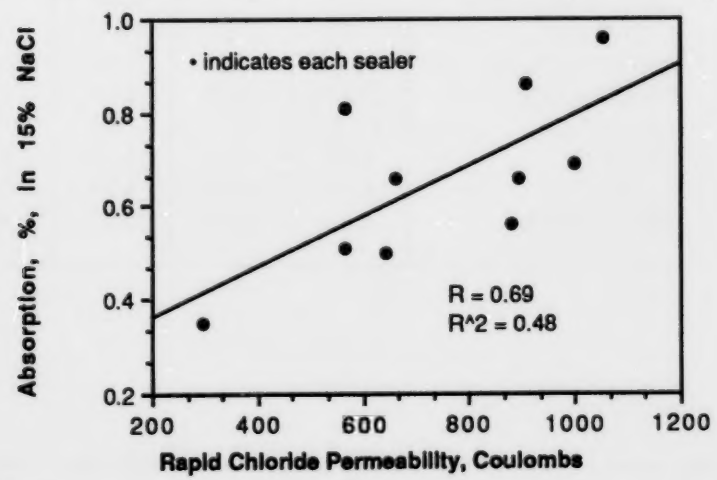


FIGURE 3: Absorption in 15 % NaCl vs Rapid Chloride Permeability



It can be seen that fairly good correlation (R = .83) exists between rapid chloride permeability and the soluble chloride ion content. The rapid chloride permeability shows only moderate correlation with the absorption in 15% NaCl.

6.0 Field Performance

In 1984 several trials were carried out using Dekguard, Cap Seal X and SN 502 applied to new barrier walls. Monitoring of these sections indicates that no scaling has occured on the sections treated with Dekguard and SN 502. Some sections treated with Cap Seal X show some scaling. The degree of salt scaling is proportional to the salt scaling observed on the adjacent untreated sections. This indicates that the treatments with Cap Seal X have not prevented salt scaling, merely reduced the rate and extent of the damage [11].

7.0 GENERAL DISCUSSION AND REQUIREMENTS

In the field a sealant may be required to protect the concrete against scaling and/or chloride ion penetration. These situations will be examined separately.

All of the sealants approved in MI-79 are still being recommended with the exception of Cap Seal X. Cap Seal X is not being recommended for use because of poor test results in this report and also poor field performance. Dekguard and SN 502 are showing good field performance to date.

7.1 Scaling

Sealant used on concrete without reinforcing steel, such as sidewalks and median barriers, should protect the concrete against scaling.

All of the sealants tested, with the exception of Chemtrete, Hydrozo 650 and Cap Seal X, showed adequate scaling resistance.

7.2 Chloride Ion Penetration

Sealants used on concrete containing reinforcing steel, such as bridge barrier walls, must protect the concrete from ingress of chloride ions which will cause corrosion and eventually spalling of the concrete.

Protection from chloride ions was determined from the results of the following four tests:

i) 15% NaCl absorption - air entrained concrete.

ii) 15% NaCl absorption - non-air entrained concrete.

iii) soluble chloride ion content - air entrained concrete.

iv) soluble chloride ion content - non-air entrained concrete.

Acceptable sealants for protection from chloride ions were defined as those showing 70% reduction from the untreated control in 3 out of the previously mentioned 4 tests with at least 65% reduction in the fourth test.

Sealants meeting this requirement are SM Deck Seal, Saltguard 12%, SN 502, Hydrozo 30M and Hydrozo 650.

7.3 Scaling and Chloride Ion Penetration

All of the sealants which met the requirement for chloride ion penetration also met the scaling requirement with the exception of Hydrozo 650.

8.0 CONCLUSIONS AND RECOMMENDATIONS

1) Use of Surface Sealants (taken from MI-79)

Surface sealants are very expensive. They should be used only when there is a reasonably high probability that the concrete will scale without some protection or chlorides will penetrate the concrete at a faster than normal rate due to insufficient cover and cause corrosion of the reinforcing bars. Instances where sealants can be used are:

i) When concrete will not be sufficiently cured to reach a strength adequate for freeze-thaw resistance.

ii) When the air void system of the concrete is deficient.

iii) When the strength of the concrete is inadequate.

iv) When the concrete has scaled prematurely and the scaling will continue to worsen.

v) When there is less than 40 mm concrete cover to the reinforcing steel.

vi) When there is a very severe exposure such as that of concrete surfaces under open bridge deck expansion joints.

Sealants should not normally be applied to adequately cured and air entrained concrete that meets the strength requirements and that has sufficient cover to the steel. This concrete is already adequately durable and it does not normally require any special protective measures.

The surfaces to receive the sealant must be lightly sandblasted and the sealant should be applied in accordance with the manufacturer's directions.

2) Sealants recommended for protection against scaling alone are as follows:

- Hydrozo 30M
- Saltguard 12%
- CPD Paver
- SM Deck Seal
- SN 502
- Stifel S
- Protekrete
- Dekguard
- System 90-11
- E. A. Sealer*
- Penseal 50*

* For use only where the concrete will be able to breathe through other than the sealed surface.

3) Sealants recommended for protection against ingress of chloride ions are as follows:

- SM Deck Seal
- Saltguard 12%
- SN 502
- Hydrozo 30M
- Hydrozo 650
- Dekguard
- System 90-11
- E. A. Sealer*
- Penseal 50*

4) Sealants recommended for protection against scaling and ingress of chloride ions are as follows:

- SM Deck Seal
- Saltguard 12%
- SN 502
- Hydrozo 30M
- Dekguard
- System 90-11
- E. A. Sealer*
- Penseal 50*

5) The rapid chloride permeability test using D. Whiting's procedure (see Sectin 4.10) shows promise as a quick test to compare the performance of sealants. Actual values obtained should not be looked at individually,

but comparisons can be made with other sealants applied to the same batch of concrete.

Study of this procedure on non-air entrained specimens is continuing and further work should be undertaken to examine this procedure in more detail.

ACKNOWLEDGEMENT

The authors would like to thank the staff of our Concrete Mix Design Laboratory, especially Edmond Wong who helped co-ordinate the testing program and assembled the data used in this report.

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APPENDIX A

TABLE H: ABSORPTION IN WATER*

AIR ENTRAINED CONCRETE

Days of Testing	Control	Hydrozo 30M	Hydrozo 650	Saltguard 12%	CPD Paver	Chemtrete BSM 40	SM Deck Seal	Cap Seal X	Nitocote SN 502	Stifel S	Protekrete
Soaking in Water											
1d	1.54	0.19	0.18	0.16	0.14	0.43	0.08	0.31	0.19	0.23	0.22
3d	1.87	0.48	0.43	0.38	0.43	0.81	0.19	0.65	0.38	0.41	0.83
7d	2.06	0.85	0.76	0.59	0.89	1.29	0.43	1.07	0.64	0.73	1.15
14d	2.21	1.19	1.01	0.72	1.20	1.65	0.58	1.43	0.91	1.01	1.91
21d	**2.32**	**1.45**	**1.30**	**0.98**	**1.40**	**1.94**	**0.76**	**1.69**	**1.20**	**1.35**	**2.13**
Drying in Air											
1d	1.45	0.96	0.83	0.71	1.01	1.24	0.48	1.10	0.68	0.90	1.32
3d	1.15	0.75	0.63	0.55	0.76	0.96	0.33	0.86	0.48	0.69	0.70
7d	0.86	0.53	0.43	0.35	0.53	0.70	0.16	0.61	0.28	0.47	0.58
14d	0.65	0.34	0.27	0.20	0.33	0.48	0.01	0.41	0.11	0.29	0.30
21d	**0.45**	**0.16**	**0.11**	**0.05**	**0.14**	**0.29**	**-0.14**	**0.24**	**-0.06**	**0.13**	**0.13**

NON-AIR ENTRAINED CONCRETE

Days of Testing	Control	Hydrozo 30M	Hydrozo 650	Saltguard 12%	CPD Paver	Chemtrete BSM 40	SM Deck Seal	Cap Seal X	Nitocote SN 502	Stifel S	Protekrete
Soaking in Water											
1d	1.30	0.16	0.19	0.19	0.19	0.36	0.09	0.30	0.17	0.20	0.22
3d	1.41	0.23	0.33	0.32	0.36	0.74	0.15	0.60	0.34	0.46	0.44
7d	1.60	0.46	0.51	0.49	0.63	1.11	0.27	0.93	0.55	0.67	0.71
14d	1.63	0.64	0.69	0.62	0.80	1.46	0.34	1.29	0.82	1.09	1.27
21d	**1.76**	**0.83**	**0.90**	**0.84**	**0.93**	**1.67**	**0.48**	**1.53**	**1.09**	**1.42**	**1.75**
Drying in Air											
1d	1.16	0.57	0.61	0.57	0.68	1.20	0.33	1.15	0.80	1.00	1.22
3d	0.80	0.41	0.44	0.42	0.51	0.86	0.22	0.88	0.60	0.75	0.94
7d	0.49	0.22	0.25	0.22	0.31	0.54	0.07	0.58	0.37	0.49	0.61
14d	0.24	0.04	0.08	0.05	0.13	0.28	-0.07	0.33	0.17	0.26	0.33
21d	**0.09**	**-0.07**	**-0.02**	**-0.06**	**0.01**	**0.14**	**-0.18**	**0.19**	**0.05**	**0.12**	**0.18**

* all values are expressed as % absorption

TABLE I: ABSORPTION IN 15% NACL*

AIR ENTRAINED CONCRETE

Days of Testing	Control	Hydrozo 30M	Hydrozo 650	Saltguard 12%	CPD Paver	Chemtrete BSM 40	SM Deck Seal	Cap Seal X	Nitocote SN 502	Stifel S	Protekrete
Soaking in Water											
1d	1.70	0.14	0.19	0.18	0.15	0.23	0.11	0.25	0.13	0.16	0.13
3d	1.99	0.25	0.26	0.22	0.29	0.39	0.13	0.39	0.19	0.23	0.38
7d	2.04	0.30	0.39	0.31	0.46	0.54	0.19	0.52	0.27	0.32	0.47
14d	2.15	0.40	0.51	0.45	0.60	0.73	0.26	0.68	0.38	0.46	0.61
21d	**2.22**	**0.56**	**0.66**	**0.51**	**0.69**	**0.96**	**0.35**	**0.86**	**0.50**	**0.66**	**0.81**
Drying in Air											
1d	1.77	0.33	0.38	0.29	0.48	0.57	0.20	0.54	0.27	0.34	0.55
3d	1.51	0.23	0.28	0.20	0.34	0.43	0.12	0.42	0.16	0.23	0.31
7d	1.23	0.13	0.18	0.10	0.20	0.28	0.02	0.31	0.06	0.12	0.26
14d	1.00	0.00	0.05	-0.03	0.05	0.12	-0.11	0.16	-0.08	-0.02	0.10
21d	**0.80**	**-0.12**	**-0.08**	**-0.17**	**-0.10**	**-0.03**	**-0.26**	**0.02**	**-0.23**	**-0.16**	**-0.02**

NON-AIR ENTAINED CONCRETE

Days of Testing	Control	Hydrozo 30M	Hydrozo 650	Saltguard 12%	CPD Paver	Chemtrete BSM 40	SM Deck Seal	Cap Seal X	Nitocote SN 502	Stifel S	Protekrete
Soaking in Water											
1d	1.55	0.12	0.11	0.11	0.12	0.25	0.07	0.17	0.13	0.15	0.18
3d	1.85	0.21	0.20	0.18	0.28	0.40	0.11	0.32	0.16	0.16	0.18
7d	2.02	0.26	0.33	0.30	0.56	0.74	0.17	0.60	0.28	0.37	0.33
14d	2.11	0.46	0.53	0.43	0.79	1.10	0.23	0.91	0.47	0.85	0.55
21d	**2.13**	**0.65**	**0.66**	**0.54**	**0.84**	**1.34**	**0.26**	**1.12**	**0.61**	**1.15**	**0.79**
Drying in Air											
1d	1.72	0.44	0.44	0.36	0.69	1.08	0.17	0.84	0.43	0.87	0.54
3d	1.51	0.36	0.36	0.28	0.57	0.96	0.12	0.73	0.33	0.74	0.45
7d	1.28	0.26	0.26	0.18	0.43	0.79	0.04	0.60	0.23	0.60	0.33
14d	1.06	0.16	0.18	0.10	0.29	0.63	-0.04	0.46	0.13	0.44	0.22
21d	**0.94**	**0.09**	**0.12**	**0.03**	**0.21**	**0.53**	**-0.10**	**0.36**	**0.06**	**0.35**	**0.14**

* all values are expressed as % absorption

TABLE J: SALT SCALING RESULTS*

# of Cycles	Control	Hydrozo 30M	Hydrozo 650	Saltguard 12%	CPD Paver	Chemtrete BSM 40	SM Deck Seal	Cap Seal X	Nitocote SN 502	Stifel S	Protekrete
Air Entrained Concrete											
5	0.041	0.009	0.007	0.007	0.008	0.012	0.007	0.008	0.008	0.008	0.009
10	0.083	0.017	0.012	0.009	0.012	0.019	0.010	0.014	0.012	0.016	0.020
15	0.102	0.018	0.023	0.011	0.017	0.029	0.012	0.024	0.022	0.023	0.035
20	0.119	0.022	0.034	0.011	0.018	0.033	0.012	0.032	0.025	0.026	0.053
25	0.134	0.028	0.051	0.013	0.024	0.047	0.013	0.064	0.031	0.031	0.069
30	0.147	0.032	0.061	0.015	0.029	0.108	0.013	0.145	0.038	0.033	0.089
35	0.155	0.041	0.104	0.019	0.043	0.339	0.017	0.299	0.050	0.044	0.096
40	0.158	0.047	0.135	0.021	0.057	0.630	0.018	0.460	0.065	0.052	0.104
45	0.164	0.053	0.154	0.024	0.077	0.924	0.030	0.585	0.078	0.061	0.115
50	**0.171**	**0.057**	**0.161**	**0.027**	**0.081**	**1.116**	**0.030**	**0.673**	**0.089**	**0.070**	**0.126**
Non Air Entrained Concrete											
5	1.413	0.006	0.008	0.000	0.002	0.011	0.002	0.003	0.002	0.014	0.002
10	2.408	0.018	0.019	0.003	0.003	0.025	0.006	0.018	0.005	0.022	0.012
15	3.117	0.031	0.046	0.007	0.006	0.035	0.007	0.034	0.010	0.028	0.038
20	3.566	0.049	0.131	0.011	0.012	0.043	0.009	0.064	0.013	0.032	0.043
25	3.927	0.082	0.323	0.020	0.022	0.059	0.011	0.200	0.018	0.036	0.048
30	4.275	0.141	0.749	0.041	0.057	0.102	0.023	0.548	0.032	0.046	0.069
35	4.534	0.189	1.081	0.076	0.086	0.151	0.025	1.199	0.059	0.050	0.077
40	4.942	0.256	1.398	0.122	0.130	0.310	0.031	1.915	0.192	0.054	0.082
45	5.270	0.318	1.606	0.195	0.181	0.548	0.031	2.348	0.392	0.058	0.085
50	**5.598**	**0.444**	**1.862**	**0.392**	**0.438**	**1.037**	**0.054**	**2.632**	**0.658**	**0.084**	**0.116**

* all values are expressed as mass loss in Kg/m2

TABLE K: VAPOUR TRANSMISSION*

AIR ENTRAINED CONCRETE

Days of Testing	Control	Hydrozo 30M	Hydrozo 650	Saltguard 12%	CPD Paver	Chemtrete BSM 40	SM Deck Seal	Cap Seal X	Nitocote SN 502	Stifel S	Protekrete
WATER											
1d	37.4	34.1	36.2	28.6	27.5	36.2	36.6	34.8	43.3	33.6	38.0
3d	50.6	48.2	51.4	44.7	45.2	50.7	56.7	49.4	60.0	49.4	67.0
7d	62.9	63.9	67.2	64.9	61.9	63.9	79.9	64.1	77.1	65.6	72.8
14d	71.8	76.6	79.6	80.2	76.4	75.2	98.8	75.9	91.2	78.6	85.9
21d	80.6	89.2	91.8	96.2	90.2	85.0	119.3	86.2	105.2	90.8	93.9
15% NACL											
1d	20.2	41.4	42.3	44.1	30.8	41.1	41.1	37.3	46.2	47.6	32.6
3d	32.0	59.4	57.6	61.4	50.0	55.7	64.2	51.2	67.8	65.2	61.4
7d	44.5	76.2	72.4	81.3	70.6	70.8	93.4	63.8	87.8	81.5	68.7
14d	55.1	99.8	93.3	107.2	93.3	87.8	131.4	81.1	116.7	103.5	87.9
21d	64.1	122.0	112.2	133.8	115.0	102.9	174.5	98.0	145.6	124.5	103.1

NON-AIR ENTRAINED CONCRETE

WATER											
1d	34.0	31.7	32.6	32.1	27.8	28.3	31.0	24.9	27.8	29.2	30.3
3d	54.2	50.5	50.6	49.9	46.1	48.6	53.4	42.3	45.2	46.9	46.2
7d	72.6	74.2	72.5	74.0	67.2	67.9	85.1	62.0	66.9	65.5	65.1
14d	86.3	95.3	91.2	94.1	86.9	83.1	114.5	78.6	85.6	81.4	81.2
21d	95.0	108.6	102.3	106.8	99.8	91.8	136.8	88.1	96.3	91.6	90.2
15% NACL											
1d	19.4	33.0	32.8	33.2	19.4	19.2	34.1	24.8	30.6	24.1	31.4
3d	29.0	44.1	45.6	47.6	33.4	28.5	53.7	34.4	46.2	35.3	42.8
7d	39.8	60.9	60.1	66.1	50.4	40.8	85.1	46.7	63.5	47.8	58.1
14d	50.3	75.6	73.6	82.5	67.3	53.1	114.4	59.1	79.4	61.2	72.2
21d	55.9	86.1	82.8	94.4	76.8	60.5	142.1	67.9	90.9	69.1	82.1

* all values are expressed as the amount of water lost during drying compared to the amount gained during soaking

APPENDIX B LIST OF SUPPLIERS

Sealants

Hydrozo 30M Hydrozo 650	Sternson Construction Products 40 Shaft Rd. Etobicoke, Ontario M9W 4M2 (416) 249-3316
Saltguard 12% CPD Paver	Construction Products Distribution Services 219 Connie Cres. Unit 14 Concord, Ontario L4K 1L4 (416) 669-5013
SM Deck Seal	Canadian Barrier (1988) Limited 119 Walgreen Rd. R.R. 3 Carp, Ontario K0A 1L0 (613) 836-6885
Dekguard SN 502 E. A. Sealer	Fosroc Construction Chemicals Foseco Canada Inc. 361 Speedvale Ave. W. Guelph, Ontario (519) 822-6440
Stifel S	Dayton Superior Limited 230 Belfield Rd. Rexdale, Ontario M9W 1H3 (416) 249-7449
System 90-11 Protekrete	DRE Industries Inc. 4174 Dundas St. W., Suite 205 Toronto, Ontario M8X 1X3 (416) 233-1603 (416) 233-7593
Penseal 50	American Metaseal Company 509 Washington Ave. Carlstadt, New Jersey 07072 U. S. A. (201) 933-1720